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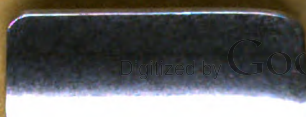
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#107-110

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

WHAT CAN BE DONE IN DESTROYING THE COTTON BOLL WEEVIL DURING THE WINTER.

By W. D. HUNTER,

In Charge of Southern Field Crop Insect and Tick Investigations.

IMPORTANCE OF WINTER WORK.

The boll weevil attracts greatest attention during the growing season of cotton, for the simple reason that its damage is then most evident. When the infested squares are falling by millions every day the planter is driven to most strenuous efforts to check the loss. The summer season, however, is the one in which it is most difficult to combat the weevil. The pest can be attacked in various ways at different seasons of the year. This circular attempts to point out what can be done in the winter when the weevils are in hibernating quarters and when natural conditions are assisting the farmer greatly by reducing the number that will be able to survive until spring. At this time the farmer can undoubtedly accomplish more than by hand-picking weevils and squares or any other direct method of control that can be put into operation in the summer season. A great advantage that winter work has in many cases is that it involves no special outlay and consequently adds nothing to the cost of producing cotton. The work can be done during the quiet period of the winter and at such times as will not interfere with the general work of the plantation. Even on plantations run largely or entirely by "wages hands" this work would undoubtedly warrant an outlay on the part of the planter. As a matter of fact the winter season could well be made the most active of the year as far as the destruction of the weevil is concerned.

It is true that the Texas farmers have not paid much attention to work against the weevil in the winter, but this does not by any means indicate that such work will not be of prime importance to the planters in Louisiana and Mississippi. Nature has afforded the Texas farmer many advantages over the planter in the eastern part of the cotton belt. As has been pointed out in other publications of the Bureau of Entomology, the Mississippi Valley planter will be compelled to contend against many more weevils each spring than the climatic conditions in Texas have ever permitted to survive. For instance, in the spring of 1908 it was determined by Mr. Wilmon Newell, secretary of the State crop pest commission of Louisiana, that as many as 6,000 hibernated weevils per acre made their appearance in certain cotton fields in Avoyelles Parish, Louisiana. This shows a survival of weevils far beyond what has ever been found in Texas. There are many other indications of the special seriousness of the weevil problem in the Mississippi Val-

ley. All this demonstrates that the planters in regions recently invaded by the weevil must resort to every means of control that is known and must utilize to the fullest extent such methods as the Texas farmers may not have been compelled to practice.

The all-important step in the control of the weevil is the destruction of millions of individuals and the prevention of the development of many more by uprooting and burning the cotton plants in the fall. This is a step that indications show clearly is going to be indispensable in the Mississippi Valley. In the light of what is now known it would be folly for planters to attempt to produce cotton unless they follow this practice religiously. If, for any reason, the cotton plants have not been removed in the fall, some good can be accomplished by their removal later in the season. The proper thing to be done by the planter who desires to reduce weevil damage to the minimum is to combine the fall destruction of the plants with such measures, to be taken later in the season, as are outlined in this circular. *The advice now given is not to depend upon winter work altogether for the control of the weevil. The winter work is merely a second step, to be taken in connection with the destruction of the weevils and the prevention of the maturity of the fall broods by uprooting and burning the plants. Where that step has not been taken, the work outlined in this circular is the main dependence of the planters at this time.*

WHERE WEEVILS ARE TO BE FOUND DURING THE WINTER.

The whole question of what can be done to destroy the weevils in the winter depends upon where they are to be found. The Bureau of Entomology has taken pains to determine the localities in which the weevils secrete themselves during the winter months. Some weevils fly outside of the cotton fields into the timber before frost has killed the cotton. Of course, such individuals as fly great distances from the cotton fields, or into heavy timber, are entirely beyond the reach of the planter. The remainder of the weevils, however—those remaining in and about the cotton fields—are more or less at the mercy of the planter for several months during the winter.

In cotton fields and in their immediate vicinity weevils have been found hibernating in four principal situations: *First*, in burrs and unopened bolls on the plants; *second*, in bolls or portions of bolls that have been knocked to the ground; *third*, under such trash as leaves and grass abounding in most cotton fields; *fourth*, in the cracks in the ground caused by drying.

The numbers of weevils found in the situations just mentioned show clearly what opportunities the farmer has for their destruction. On January 16, 1907, a field near Wolfe City, Tex., showed from 363 to 1,500 live weevils per acre in the burrs still hanging to the plants. These were generally in the partly opened locks where weevils had matured in the fall, but some were in locks from which all of the cotton had been removed. On January 27, 1907, as many as 2,250 weevils per acre were found on the ground in a cotton field near Dallas, Tex. The number was determined by raking all of the trash carefully from a square rod of ground and examining it in the laboratory. On December 18 living weevils at the rate of 1,056 per acre were found at Dallas. On January 16 320 living weevils per acre were found in burrs and under leaves and grass in a cotton field at Victoria, Tex. On Novem-

ber 15 4 weevils were found in the cracks around the bases of 22 cotton plants growing near Dallas. This indicates a total number of weevils per acre in such situations in this field of 1,090.

Practically all of the weevils to be found in the situations described can be killed by raking and burning the trash, except those in cracks in the ground, and these, in the majority of cases, would probably be crushed by winter plowing of the fields.

PLOWING NOT EFFECTIVE.

The point may be raised that winter plowing, by burying the weevils found in trash on the surface, might have the same effect as burning. On the contrary, experiments have shown that weevils can easily make their way through several inches of soil. Consequently such work in general is as likely to protect as to destroy the weevils. Of course, if heavy rains should follow immediately after plowing, it is possible that some soils would be so compacted as to prevent the emergence of weevils. Nevertheless, this could not happen under usual conditions. In the case of weevils in cracks, destruction would not result from burial but from crushing.

What has just been stated should not be taken to mean that winter plowing should not be followed. As a matter of fact, the winter working of the fields should be practiced, not only on general principles, but to assist in procuring an early crop. The present purpose is merely to point out how to destroy the boll weevil in the winter. Regardless of its other benefits, winter plowing can not be depended upon to actually kill many weevils.

WEEVILS THAT CAN BE REACHED OUTSIDE OF COTTON FIELDS.

In addition to those in the cotton fields themselves, many weevils can be reached that have found winter quarters along turn-rows, in ditches, along fences, and in the trash that is frequently allowed to accumulate around seed houses. Fire is again the agent of destruction at the command of the farmer. Careful burning of turn-rows and ditches and cleaning of fence corners and similar situations will result in the death of many weevils that might survive to damage the crop of the following season.

The work of burning and cleaning the plantation should not stop with the immediate vicinity of cotton fields. Many weevils fly into corn fields, where they find suitable quarters for passing the winter. These fields, on a cotton plantation, should be cleaned during the winter as thoroughly as the fields where cotton has been growing or is to be grown during the next season. It has been found that sorghum fields furnish exceptionally favorable opportunities for hibernating weevils. The heavy stubble left by this crop catches grass and general débris blown about by the wind, which then becomes heavily matted. Here many weevils are to be found during the winter. In many cases in Texas the earliest appearing weevils and the greatest damage to the crop have been shown to be chargeable to neighboring sorghum fields which have served as winter quarters for the pest.

Many weevils undoubtedly find hibernating quarters in trash along railroad rights of way as well as along wagon roads. The importance of such means furnished the weevil for passing the winter becomes great where, as in many cases, the roads or railroads pass through localities

where cotton fields adjoin the public property. It should be the duty of railroad and county authorities in such cases to assist the farmers as far as practicable by removing the shelter for the weevil.

WEEVILS IN COTTON SEED.

Cotton seed has frequently been supposed to furnish exceptionally favorable winter quarters for the weevil. It has been shown that many weevils pass through the gins and are later to be found in the bulk cotton seed in storage. Up to a certain time in the winter cotton seed is very likely to contain live weevils. Many experiments, however, have shown that very few are able to survive in this medium until spring. This seems to be due principally to the absence of moisture. Repeatedly numbers of weevils have been placed in cotton seed in the fall. Altogether 6,600 weevils have been used in these experiments. They were placed under a variety of conditions. Although many have survived until the middle of winter, only two lived until the first of April. It is therefore clear that cotton seed itself is not an especially dangerous commodity. Although it is true that the earliest weevils frequently make their appearance in the vicinity of seed houses, this is to be accounted for by the fact that the insects find quarters under the building and under the trash that is allowed to accumulate in such situations rather than in the cotton seed itself.

CONCLUSION.

The climatic and labor conditions surrounding cotton production in Louisiana and Mississippi leave no doubt that the planters in those States must not overlook any important means of controlling the boll weevil. *This circular points out one important and inexpensive means that can be practiced by every planter.* It is of special importance in the humid regions recently invaded where fears of disaster are now commonly entertained. The Department of Agriculture urges that cotton raisers take advantage of the enemy while they have the opportunity and by the means herein described greatly increase the chances for producing a crop the coming season.

Approved:

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., December 19, 1908.

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CIRCULAR NO. 108.

Issued February 11, 1909.

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

HOUSE FLEAS.

By L. O. HOWARD.

Judging from the specimens of fleas sent to the Bureau of Entomology of recent years with complaints of houses being infested by them, the human flea (*Pulex irritans* L.) is not the species most likely

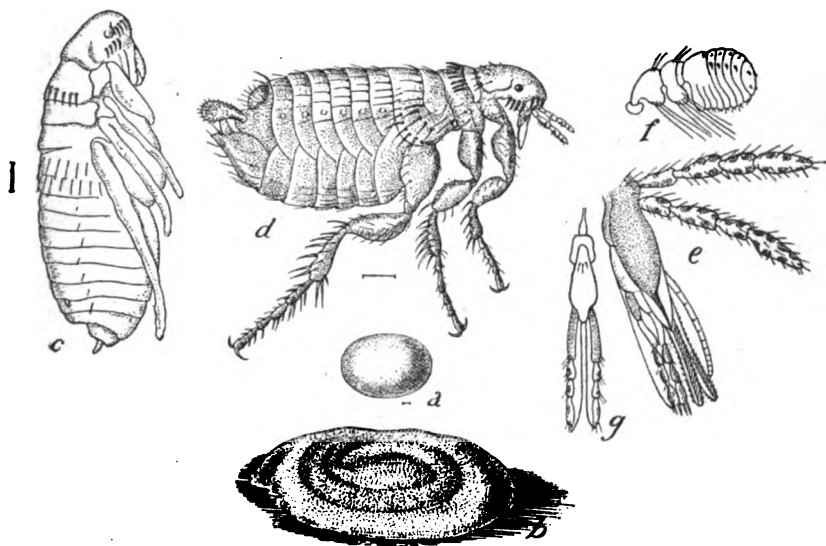


FIG. 1.—Cat and dog flea (*Ctenocephalus canis*): a, Egg; b, larva in cocoon; c, pupa; d, adult; e, mouth-parts of same from side; f, antenna; g, labium from below. b, c, d, Much enlarged; a, e, f, g, more enlarged. (Author's illustration, redrawn.)

to occur in great numbers in dwelling houses in this country, but rather the common, cosmopolitan flea of the dog and cat (*Ctenocephalus canis* Curtis).^a This holds especially for the eastern

^a In the earlier publications of this office, Bulletin 4 and Circular 13, this species has been referred to under the name *Pulex serraticeps* Gerv.

United States. *Pulex irritans* is sometimes found in houses in California, and is the prevailing household flea of Europe. A house may become infested with the cat and dog flea even though no domestic animals be kept, for a visitor at a house where such pets are maintained may be the means of carrying home with him one or two female fleas which will stock his own premises. Of course, where a pet dog or cat is kept, the source of the infestation is manifest.

The worst cases of infestation reported to this Bureau have usually been those in which houses had been temporarily unoccupied during the summer. Such houses during a rainy summer become more or less damp, and as a rule the customary sweeping of the floors is interrupted, thus furnishing the very conditions under which, as we shall see, fleas most readily propagate.

The eggs (fig. 1, *a*) of *Ctenocephalus canis* are deposited among the hairs of cats and dogs, but as they are not attached to the hairs, numbers drop off whenever the infested animal moves or lies down. From these eggs hatch the larvæ (fig. 2, *a*), which are slender, minute, white, wormlike creatures. They are very active, crawl rapidly, penetrate into the cracks of the floor, and live there until full grown, feeding upon such organic matter as may have collected in the cracks. They develop rapidly, and in midsummer in Washington reach full growth in a short time. On reaching full growth the larva spins a delicate, white, silken cocoon (fig. 1, *b*), and transforms to pupa (fig. 1, *c*), the adults (fig. 1, *d*) issuing a few days later. A whole generation may develop in the course of a fortnight in warm, damp weather, but a great excess of moisture results in the destruction of the larvæ. With this rapid development under the most favorable conditions, a housekeeper, shutting up her house in June, for example, with a colony of fleas too small to be noticed inside the house, should not be surprised to find the establishment overrun with fleas when she opens it again in September or October.

REMEDIES.

If you do not desire to be troubled by fleas, do not keep cats or dogs. If you must keep a pet dog or cat, provide a rug for the animal to sleep on, and give this rug a frequent shaking and brushing, afterwards sweeping up and burning the dust thus removed. As all the flea eggs on an infested animal will not, however, drop off in this way, and as those which remain on it will probably develop successfully, it will be found wise to occasionally rub into the hair of the dog or cat a quantity of pyrethrum powder. If thoroughly applied, this powder will cause the fleas to fall off in a half stupefied condition, when they, too, may be swept up and burned.

The larvæ of the dog and cat flea will not develop successfully in situations where they are likely to be disturbed. The use of carpets

and straw mattings, in the writer's opinion, favors their development, since the young larvæ can penetrate the interstices of either sort of floor-covering and find an abiding place in some crack where they are not likely to be disturbed. It is comparatively easy to destroy the insect in its early stages (when it is noticed), but the adult fleas are so active and so hardy that they successfully resist any but the most strenuous measures. Even the persistent use of California buhach and other pyrethrum powders was ineffectual in one case of extreme infestation, as was also, and more remarkably, a free sprinkling of floor mattings with benzine. In this instance it was finally necessary to take up the floor-coverings and wash the floors down with hot soapsuds in order to secure relief from the flea plague. In another case, however, a single liberal application of buhach was perfectly successful, while in a third a single thorough application of benzine completely rid an infested house of fleas.

In bad cases almost nothing will avail without the greatest care in keeping the floor and other coverings, as well as crevices, etc., free from dust and dirt. The old remedy often mentioned of putting a piece of raw meat upon a sheet of sticky fly paper, in the hope that the fleas will jump for the meat and be caught by the fly paper, has been thoroughly tried by the writer without success. Where there are comparatively few fleas in a house or in a given room, the following somewhat laborious plan will result in eradication. Place a white cloth, like a pillowcase, in the middle of the floor. The fleas, attracted by the white color, will jump on the cloth. Then, with a basin of water, kneel down and with the wetted forefinger pick up the fleas one after another and put them in the water. The writer has known several houses in Washington to be rid of rather sparse populations of fleas in this manner.

Mr. E. M. Ehrhorn, of San Francisco, gives the following remedy, which he states he has tested and which his mother used with effect in South America. Fill a glass three-fourths with water, on top of which pour about an inch of olive oil, then place a night float (a little wick inserted in a cardboard disk or in a cork disk) in the center of the oil. Place the tumbler in the center of a soup plate filled with strong soapsuds. The wick should be lighted at night on retiring, or may be used in any dark room. As the soup-plate-soapsuds trap is placed on the floor of the room it does not interfere with the sleeper, and the fleas which are on the floor are attracted to the light. For outbuildings, such as barns, etc., a large milk pan may be used, and instead of using olive oil and a glass, a stable lantern may be placed in the center of the pan, while instead of soapsuds a scum of kerosene may be put on the water in the milk pan.

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To sum up: Every house where a pet dog or cat is kept may become seriously infested with fleas if the proper conditions of moisture and freedom from disturbance exist. Infestation, however, is not likely to occur if the (bare) floors can be frequently and thoroughly swept. When an outbreak of fleas comes, however, the easiest remedy

to apply is a free sprinkling of pyrethrum powder in the infested rooms. This failing, benzine may be tried, a thorough spraying of carpets and floors being undertaken, with the exercise of due precaution in seeing that no lights or fires are in the house at the time of the application, or for some hours afterwards. Finally, if the plague is not thus abated, all floor coverings must be removed

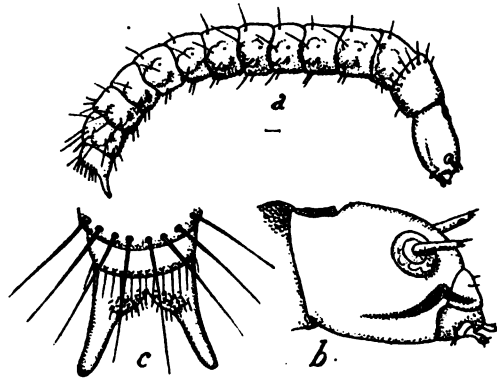


FIG. 2.—Cat and dog flea (*Ctenocephalus canis*): a, Larva; b, head of same; c, anal end of same. a, Much enlarged; b, c, more enlarged. (Author's illustration, redrawn.)

and the floors washed with hot soapsuds. This is a useful precaution in any house which it is proposed to close for the summer, since even a thorough sweeping may leave behind some few flea eggs from which an all-pervading swarm may develop before the house is reopened.

Approved:

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., December 29, 1908.

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CIRCULAR NO. 109.

Issued July 6, 1909.

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

THE LEOPARD MOTH.

(*Zeuzera pyrina* Fab.)^a

By L. O. HOWARD and F. H. CHITTENDEN.

INTRODUCTORY.

Deciduous trees of many kinds, grown for shade and for ornament in northern New Jersey and eastern New York, are subject to severe injury by the larval stage of the European leopard moth (*Zeuzera pyrina* Fab.). Among the shade trees, elms and maples suffer the greatest damage, but as this species is a very general feeder it attacks practically all descriptions of trees and shrubs with the exception of the evergreens. In the region mentioned this species is, everything considered, the most serious menace to the growth of shade trees, since, unlike the majority of lepidopterous insects, the larvæ of the leopard moth do not feed upon the foliage, but bore into the branches of the plants which they infest and feed upon the living wood. The larvæ usually begin operations in twigs and small branches and with their larger growth bore and tunnel into the larger branches and trunks. This work has the effect of girdling, the injured portions being blown down by heavy wind storms, while in the case of severe attack the growth of the tree is checked, frequently causing its death. Attack is not confined solely to shade and ornamental plants, but orchards are often injured.

DESCRIPTIVE.

Injury by this species is accomplished solely by the larva, which is a fleshy, grublike caterpillar, pale yellowish in color, frequently with a pinkish tinge. The head, thorax, and anal plates are brownish-black and the surface of the body is very sparsely hairy but covered

^a Family Cossidæ. Synonyms: *Zeuzera æsculi* L., *Z. decipiens* Kby., etc.
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with large and prominent tubercles arranged as shown in the illustration (fig. 1, *c*). When fully mature the larva attains a total length of about 2 inches. A lateral view of the larva in its burrow is shown in figure 1 at *c*.

This species derives its name from the spotted appearance of the moth, illustrated at figure 1, *a*, *b*. There is great diversity in the size of the two sexes, the female (*a*), which is a heavy-bodied moth and a very feeble flyer, being much the larger. It will be noticed that the smaller male (*b*) has a more slender body, which permits a more ready flight, and is also distinguished from the female by the pos-

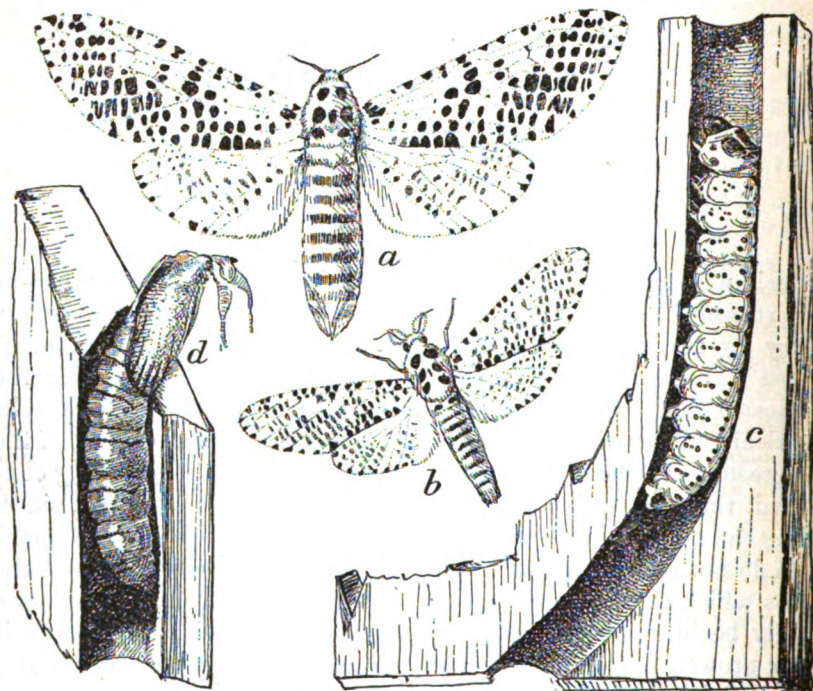


FIG. 1.—The leopard moth (*Zeuzera pyrina*): *a*, Adult female; *b*, adult male; *c*, larva; *d*, empty pupal case. Enlarged. (Original.)

session of broad bipectinate or feathery antennæ. The wings are semitransparent and white, thickly dotted with blackish spots which are more or less distinctly tinged, giving them a dark blue or greenish cast. The thorax is marked with six large black spots and one small one, the latter being located in the center. The female has a wing expanse of upwards of one and a half inches, while that of the male is much less.

An empty pupa-case in its cell in the wood is shown in the illustration at *d*.

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ORIGINAL HOME AND DISTRIBUTION.

The leopard moth, like so many other dangerous pests, is a European species which has been introduced into the United States in comparatively recent years. Its old world distribution is credited as central and southern Europe, southern Sweden, southwestern Africa, Algeria, and northern Morocco, and the western portion of Asia Minor.

This species was introduced into the United States some time prior to 1879, in which year, on the authority of Mr. Jacob Doll, a living moth was captured in a spider's web at Hoboken, N. J.^a In 1884 Dr. E. B. Southwick, then entomologist of the public parks of New York City, recognized the destructive work of this species in Central Park.^b In 1887 it was seen at Newark, N. J., but was not actually recorded as occurring in this country until the following year. In 1890 the junior author observed the moths at electric lights at Orange, N. J.

Fortunately the spread of this insect, particularly in the immediate vicinity of New York City, has been very slow, a fact which may be attributed to several causes, (1) the slowness of the flight of the female, (2) the dominance of sparrows in large cities, causing our native birds, such as woodpeckers, to be driven to the country, where they destroy the moths, and (3) the bowl-shaped electric-light globes, hollow at the top and closed at the bottom, which were formerly in general use in our large cities. The males are strongly attracted to brilliant lights and many were captured and perished in these globes in earlier years. Other cities in New Jersey where this species has been troublesome are Elizabeth, Irvington, Montclair, Arlington, Asbury Park, Ocean Grove, and New Brunswick. Mr. H. M. Russell of this Bureau collected specimens at Bridgeport, Conn., in 1901. The species is now an inhabitant also of Staten Island and has spread on Long Island well beyond the confines of greater New York. Southward it was reported a pest, in 1901, at Ocean Grove, N. J., and by 1905 it was recorded by Felt as occurring at Kensico, N. Y., 25 miles north of New York City. By 1907 it was captured at New Haven, Conn., by Prof. H. W. Foote. It is now stated to be injurious in the vicinity of Boston, Mass.

FOOD PLANTS.

In its original home the leopard moth is recorded as living on a considerable number of common trees, including elm, lime or linden, ash, beech, birch, walnut, oak, chestnut, poplar, alder, and, rarely, horse-chestnut. Among orchard trees it is reported to do injury to pear, apple, and plum. In the United States it attacks all of these

^a Entomological News, March, 1904, p. 110.

^b Insect Life, Vol. VII, p. 138.

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trees and many others, the list including such important shade trees as have been mentioned, as also practically all of the maples, elms, and oaks, mountain ash, tulip tree (*Liriodendron tulipifera*), aspen, the willows, and such shrubs as privet, lilac, and honeysuckle. A list of trees which this species has been actually observed to attack was compiled in 1894 by Doctor Southwick and includes 77, observed in the public parks of New York City alone. A total list of 83 trees and shrubs was made at that time.^a

It will be seen by the list of food plants already presented that the number could be almost indefinitely extended, particularly in reservations like Central Park, New York City, and Prospect Park, in Brooklyn, where special effort has been made to bring together a great variety of trees and shrubs. The insect is, in fact, nearly omnivorous, attacking, as previously stated, practically all forms of woody plants which are of suitable size for its purpose, with the exception of conifers.

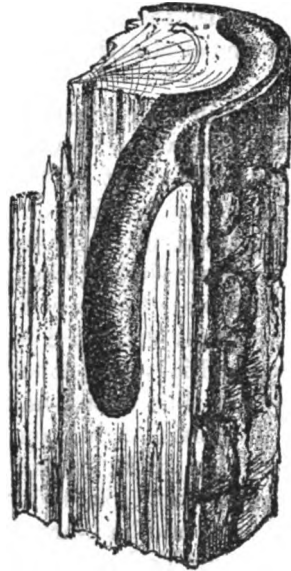


FIG. 2.—Section of wood showing burrow and girdling effect produced by larva of leopard moth. Reduced. (From Insect Life.)

HABITS AND LIFE HISTORY.

In Germany the moths are stated to make their appearance during July and August, while in this country they appear as early as May and continue issuing until late in September.

The gravid female, being particularly heavy, is unable to fly very far or very high. She deposits her oval, salmon-colored eggs in a large mass or group, when not in confinement, and as many as 300 eggs have been counted in a single mass. This is, however, probably not the maximum number, since an estimate of as many as 1,000 has been made. The eggs are in-

troduced by the rather hard ovipositor into the soft tissue of young growth where the bark is smooth, or are inserted into crevices in the rough bark of older trees.

The larvæ soon hatch—in about ten days, according to Mr. J. V. D. Walker—and penetrate the wood, frequently entering the nearest crotch but boring in at other points, and burrow tunnels into the heart or pith of twigs and the heartwood of the larger branches or trunks. When a larva has grown too large for the branch in which it is feeding it crawls out and migrates to a larger one. In a single

^a See list on page 529, Rep. Ent. N. J. Agr. Exp. Sta. for 1894. This article, by Dr. J. B. Smith, covers pages 517–533 and presents a very complete account of the insect.

tree 6 inches in diameter Southwick observed as many as six larvæ, any one of which would have been able to destroy the tree if not removed. Mr. A. Hufnal wrote that in maple trees which this species was infesting at Ocean Grove, N. J., there was an average of from six to eight borers to a tree and that he had found from ten to fifteen, and in one instance as high as thirty-four, in a single tree. By the time the larvæ within have attained full growth infested limbs of a certain size are likely to break off, especially during or after a severe storm, for the full-grown larva in many cases girdles the branch. The manner of girdling is shown at the top of the section of wood illustrated in figure 2. In 1893, after every storm in Central Park great quantities of limbs were seen, some entirely broken off and others still hanging to the trees.

The larva, when fully mature, transforms to pupa within the burrow, the change beginning to occur during the second May after the hatching of the eggs, the larva thus requiring nearly two years to complete its growth. The pupa, by means of a sharp protuberance on its head, is enabled to force its way partly out of the burrow, after which the skin splits open and the moth emerges. The empty pupal skin remains for some time projecting from the orifice.

The presence of this borer in a branch is manifested by little accumulations of chips, matted excrement, or frass, which indicate the entrance to the burrows. After a time these orifices are closed from within by a silken web, which is doubtless to protect the contained insect from its natural enemies. Smaller twigs wilt and break off and often it is only when the severed twigs or branches have been brought down in numbers by high winds that the work of the insect is first recognized. Where the larger larvæ have worked just under the bark this splits open the next season, leaving an ugly scar as a reminder of its pernicious operations.

NATURAL CHECKS.

No specific natural enemies of the leopard moth appear to have been recorded in this country, although in Europe E. A. Fitch has reared an indeterminate chalcidid of the subfamily Encyrtinæ.^a

In the explanation of the cause of the slow spread of the moth from cities and large towns to the country, allusion has been made to the fact that native birds probably assist in holding this insect in check in the suburbs. Actual observations on this head appear to be wanting, but there are the best of reasons for believing that birds, like the woodpeckers, which naturally look over the bark and collect all kinds of borers, prey on this species, while it is believed

^a Entom. Mo. Mag., Vol. XVIII, p. 116. Perhaps *Copidosoma truncatellum* Dalm., mentioned by Dalla Torre (not Mayr), Catalogus Hymenopterorum, p. 246.

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that sparrows sometimes destroy the eggs or young larvæ in such places. Smith has expressed the belief that when the insect succeeds in getting away from the outskirts of cities its enemies increase in number, many insectivorous birds aiding in holding it down.

During the day the moths must be fed upon by birds and later by bats and night-flying birds. The habit of the larvæ of deserting one twig and migrating to a larger one undoubtedly leaves them exposed to the same natural enemies, as this has been observed to happen in the daytime as well as after nightfall. It follows that the protection of native birds, especially the woodpeckers and related species, will greatly assist in restraining the undue increase of this borer.

METHODS OF CONTROL.

The protected and concealed manner of life of this species, as shown by the life history, which will apply in the main to other borers also, renders it very difficult of treatment by means of insecticides or other direct measures. The most efficacious remedial measure consists in cutting off and destroying affected branches and in the injection of bisulphid of carbon into the holes or burrows where the larvæ are at work.

Pruning and cutting back.—Twigs or branches which, by their wilting or by the frass which accumulates at the entrance to their burrows, indicate the presence of this borer, should be carefully searched out, the smaller ones pruned away and the larger ones cut back, the amputated portions being promptly burned. After windstorms, the affected branches which have fallen to the ground and those which remain attached to the tree should be collected and burned. Wherever trees show that they are past recovery it is best to take them out and promptly destroy them. The word promptly is used advisedly, for this insect, as has been shown previously, frequently migrates from one twig or branch to another.

Bisulphid of carbon.—In the case of young and rare trees and others which show only a few larval burrows in the bark, bisulphid of carbon is the best remedy and one which has been in general use against the present species in the public parks of New York City. It is injected into the openings of the burrows, and the openings are afterwards closed with various substances. For this injection a mechanic's long-spouted oil can of small size may be used on large trees, but against a related species the writers have made very good use of a small glass syringe, such as may be purchased at any drug store for ten cents. These glass syringes are most serviceable, because the exact amount of bisulphid may be seen when drawn into the syringe and because the reagent does not injure the thread pack-

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ing.^a Metal syringes may also be used, but it is more difficult to measure the exact amount and the bisulphid acts on the leather packing. Rubber syringes can not be used because of rapid corrosion. About a teaspoonful of the liquid bisulphid is sufficient for each burrow.

For stopping the holes after injecting the liquid, putty and moist clay, advised by some, have not been found so serviceable as grafting wax. Coal tar may be substituted for the latter, or the holes may be closed by inserting a wooden plug and breaking or sawing it off level with the trunk. In any case the stopper should be tight, to exclude water from rains, which might tend to produce decomposition of the surrounding wood or invite other insects, like black ants and secondary borers, of which there are many species, and injurious fungi.

Carbon bisulphid should be handled with the usual precautions against fire, which means that the operator should not smoke while at work. Although a deadly poison, it will not injure ordinary trees when applied as described.

Killing with wires.—It is possible to reach and destroy some larvæ by forcing a copper or other pliable wire into the channels. This is a well-known borer remedy. It is impossible, however, by this means to kill the insects in all cases, owing to the length or crookedness of the burrows. Bisulphid of carbon should then be used.

Electric lights.—To what extent electric lights are serviceable as an agency in the destruction of the moths of this borer has not been definitely determined. Col. Nicholas Pike and Dr. J. B. Smith, however, have advised placing shallow pans around electric-light poles in and around parks to attract the moths. The pans are partially filled with water and a few drops of kerosene are poured into them. The moths flying against the globes drop into the pans and are promptly killed when they come into contact with the oil. In this way many males can be destroyed.

Inspection.—In large parks the destruction wrought by this borer annually is an important item, and it will be found a source of profit to establish a system of inspection consisting in the employment of parkkeepers and boys, and others who may be engaged at lower

^a During the last years of the nineteenth century a long row of beautiful red oaks bordering the street between the grounds of the Department of Agriculture and those of the Smithsonian Institution were badly infested by the related carpenter worm (*Prionoxystus robinix* Forst.). Nearly every tree was infested and frequently two or three burrows showed near the tops of the trunks. Bisulphid of carbon was applied, as described above, and the holes closed with grafting wax. A year later no insects could be found at work, but wherever this remedy had been applied a small scar remained. Two years later these had entirely disappeared and the trees looked as if they had never been infested.

wages, to keep a constant lookout for evidences of borer attack on valuable trees. On this head Southwick has reported that in 1893 he spent two months in fighting this insect alone in the city parks of New York, collecting wagon loads of limbs and branches and destroying the larvæ or pupæ.

Maintaining trees in thrifty condition.—If valuable trees are to be protected, the insect should not be allowed to breed in useless growth. The borers in such trees should be destroyed or the trees promptly felled and burned. Care should be exercised in transplanting new trees, and fertilizers should be used in order that the trees may be always thrifty, the better to withstand attack. This means protecting them from the attack of aphides, scales, and defoliators, such as tussock moths and the fall webworm, and keeping them free from disease.

Finally, in the control of this species promptness and thoroughness can not be too strongly emphasized. The bisulphid of carbon remedy should always be used where applicable, and the inspection system advised should be instituted in all public parks and on city streets infested by this pest. Individual owners of valuable trees should become acquainted with the pernicious nature of this borer, and united action should be secured with neighbors who also suffer from the ravages of the pest.

NOTE.—After this publication was in type we received information that trees in the college yard of Harvard University, Cambridge, Mass., are being severely injured, the large elms being the most seriously attacked.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., May 27, 1909.

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United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

THE GREEN-STRIPED MAPLE WORM.

(Anisota rubicunda Fab.)^a

By L. O. HOWARD and F. H. CHITTENDEN.

GENERAL APPEARANCE AND METHOD OF WORK.

Maple trees grown in the United States for shade or other purpose are subject to severe injury from defoliation by caterpillars. In addition to the fall webworm^b and tussock moth caterpillar^c there is a common and troublesome species known as the green-striped maple worm (*Anisota rubicunda*) which affects maples of all kinds, including sugar maple, and is especially partial to silver and swamp maples. It feeds occasionally also on box-elder and will defoliate oak in the absence of its favorite food trees.

In its active stage this insect is a naked or hairless caterpillar (fig. 1, *d*, *e*) of large size and somewhat attractive appearance, being pale yellowish green, longitudinally striped with dark green. It is armed just back of the head, on the second thoracic segment, with a pair of long black horns. It has also a number of short, black, spiny projections along its sides and at its anal extremity. The anal segments are somewhat dilated and rose-colored on the sides. When fully grown, it measures nearly two inches in length.

The parent insect, or moth, is a beautiful creature of a pale yellow color shaded with a most delicate pink. The female is well shown in the accompanying illustration (*a*), the dark portions representing the pink, and the paler portions the yellow color. In eastern individuals the colors differ from those found in the West, the rose tints being more intense, while in the western forms the yellow predominates, with only a slight tinge of rose. Some western individuals also are nearly white. The female has a wing spread of one and three-fourths to about two inches, and her body is yellow and woolly in appearance. Her head is small, retracted into the thorax, and bears short, thread-like antennæ. The male is smaller than his mate, having plumose or feathery antennæ, as represented in the figure (*δ*).

The egg is about one millimeter in diameter, slightly flattened, and pale green, becoming yellowish before the larva hatches. A portion of

^a Formerly called *Dryocampa rubicunda* Fab.^b *Hyphantria cunea* Dru.^c *Hemerocampa* (*Orgyia*) *leucostigma* Dru.

an egg mass is figured in the illustration at *c*, and a much-enlarged egg with the embryo within at *b*. The pupa is very dark brown, nearly black, and of the somewhat peculiar form shown at *f*. It is armed with little spines on the margin of the abdominal segments and on the thorax, and the anal segment ends in a projection a little forked at the tip.

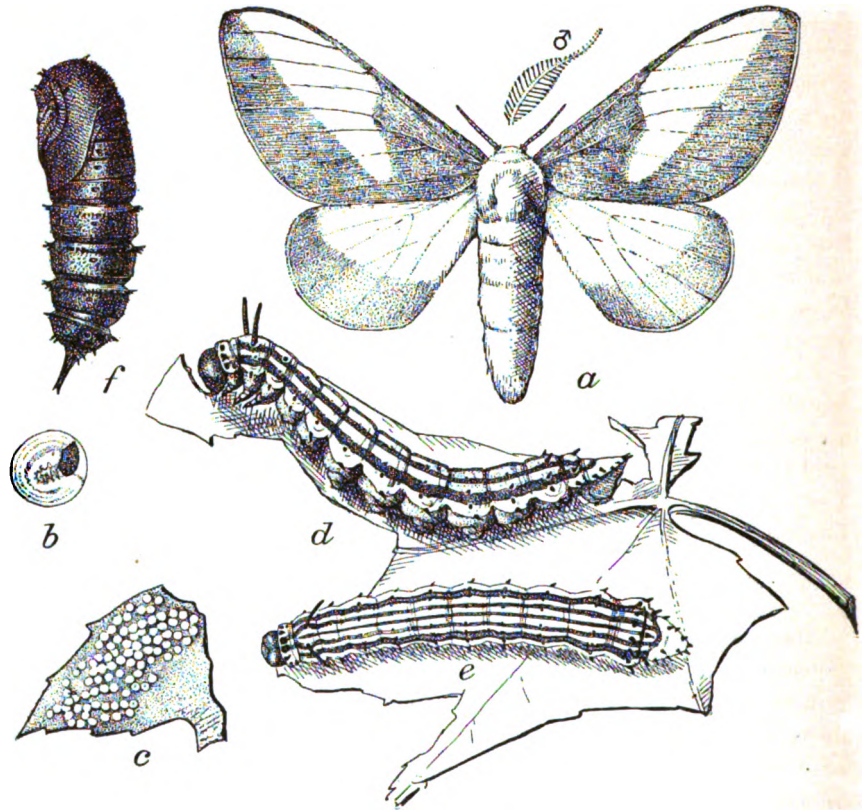


FIG. 1.—*Anisota rubicunda*: *a*, Female moth and antenna of male moth; *b*, egg, showing embryo within; *c*, portion of egg mass; *d*, full-grown larva from side; *e*, same from back; *f*, pupa. Enlarged. (Original.)

ORIGIN AND DISTRIBUTION.

The green-striped maple worm is a native North American species and is more abundant in the West than in the East, although it enjoys a considerable range. It abounds especially in Kansas, Nebraska, Missouri, Illinois, and Iowa, occurring also in the Gulf States, occasionally doing considerable damage in Mississippi. It extends sometimes in injurious numbers North and East, and has attracted some attention by its ravages in West Virginia, the District of Columbia, New Jersey, and in a limited portion of New York State. Instances

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are on record of its occurrence in great numbers in Dutchess and Sullivan counties in New York, but these occurrences were exceptional.

LIFE HISTORY AND HABITS.

The moths issue from over-wintering pupæ or chrysalides in May or June, according to locality, and pair, the females depositing their eggs on the under side of the leaves. The number of eggs laid by a single female has not been ascertained, but is known to reach at least 150. In eight or ten days the eggs hatch, and the caterpillar emerges and feeds and grows apace. After passing through four molts in about a month it reaches full growth, when it enters the ground to transform to pupa. At the end of two weeks, or a little longer, the pupa, by means of the sharp and horny projections which have already been described, works its way to the surface of the ground and gives forth the moth. Soon afterwards the female, after copulation, lays eggs for a second generation.

In the District of Columbia it has been ascertained that there are usually three generations in the course of a year, although in Missouri, according to Riley, there are only two. Pupæ of the second generation in the West and of the third generation in the East over-winter. Even as far north as Massachusetts Harris showed the probability of two generations annually.

INSTANCES OF INJURY.

Many of the earlier writers on economic entomology reported numerous instances of injury by this species, but of late the insect has not received much attention, presumably because of the far greater destructiveness of the commoner tussock moth and fall webworm, and of the gipsy and brown-tail moths. Possibly this maple worm is decreasing in numbers. Some characteristic outbreaks may be mentioned, therefore, as showing its importance some years and to give some idea of its method of work.

In 1887 Mr. H. W. Young, Independence, Kans., wrote that for four years the soft maple shade trees of that city had been defoliated twice a year by this insect, the trees being greatly weakened. In 1888 Mrs. M. T. McCluny, Sedalia, Mo., wrote that these "worms" "were like the locusts of Egypt, and filled the houses" and destroyed the leaves of the maple shade trees. In 1889 considerable correspondence was had with Mr. J. W. Merchant, Kansas City, Mo., who reported extensive defoliation in Kansas City, Kans., and sent several photographs, one of which is here reproduced (fig. 2). In cases where adjoining maple and elm trees branched into each other the elm trees were never touched. During the period from 1888 to 1890, at Lincoln, Nebr.,

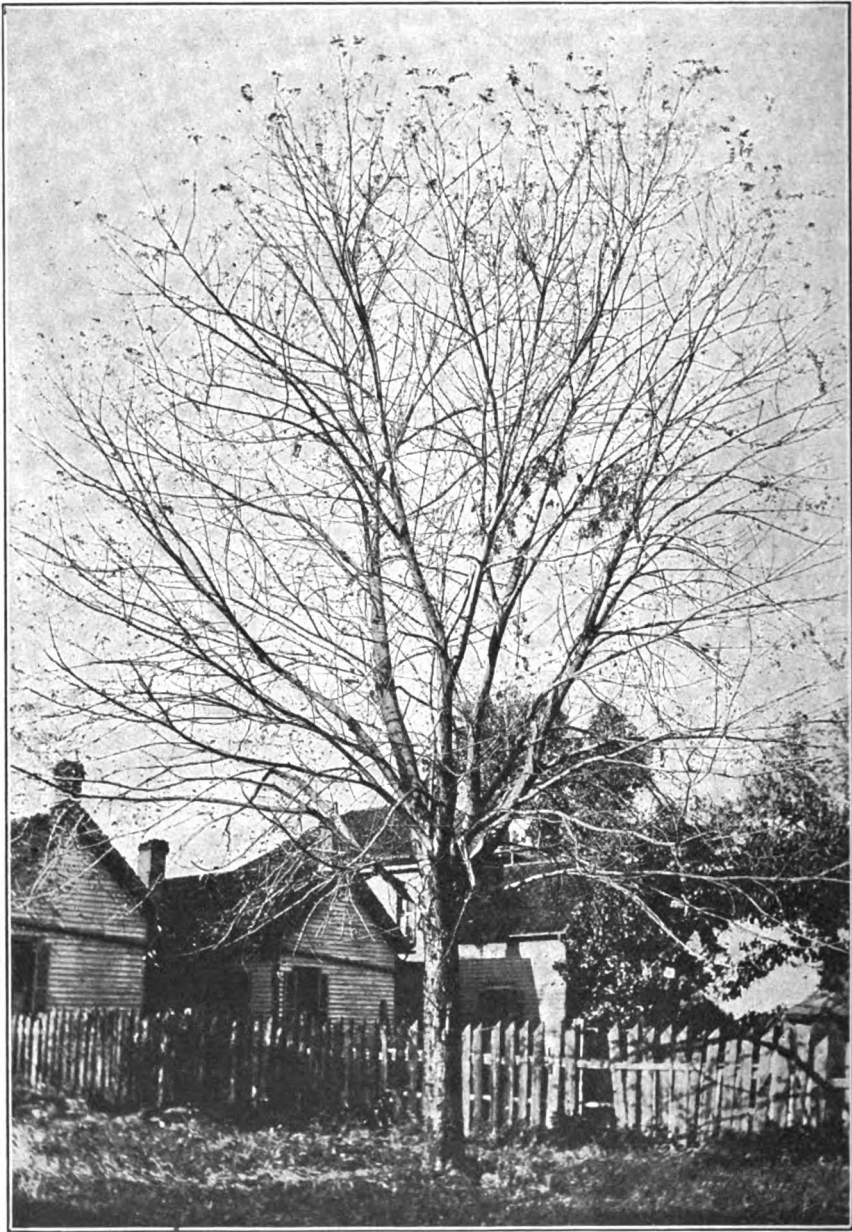


FIG. 2.—Maple tree at Kansas City, Kans., defoliated by green-striped maple worm. (Original.)

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many rows of large maples were entirely defoliated, rendering them very unsightly. (See fig. 3.) At about the same time Doctor Riley reported similar complete defoliation on the grounds of the State agricultural college at Manhattan, Kans., and of the State university at Lawrence, Kans. In 1901 Mr. F. E. Brooks reported great damage to the foliage of maple in the vicinity of French Creek, W. Va. Since 1905 the species has been abundant in portions of Maryland and Virginia, but not noticeably troublesome.

During 1908 it was devastating forests in and around Fryeburg, Me. At that time it almost entirely stripped maple and—it was said—oak, beech, birch, apple, and other deciduous trees over a very large section, but it seems probable that other species were present, as in other cases reported to this office.^a It was particularly troublesome to shade maples in Maine, New Hampshire, and Pennsylvania.

NATURAL ENEMIES.

The green-striped maple worm is frequently eaten by domestic fowls and by many birds. Of these the robin and yellow-billed cuckoo have been recorded by Bruner.^b He reports both of these birds as actively engaged in picking up and swallowing the "worms" as late as September 20, at Lincoln, Nebr. The bluebird, tufted titmouse, red-headed woodpecker, red-eyed vireo, and crow blackbird are also stated by the late Prof. F. H. Snow to eat the "worms." while the moths also are sometimes destroyed by birds. To the above list Prof. F. E. L. Beal, of the Bureau of Biological Survey, adds the black-billed cuckoo and the great-crested flycatcher as enemies of this insect.

This species is parasitized by a common ichneumon fly, *Limnerium fugitivum* Say, a rather general parasite of lepidopterous larvæ. Two tachina flies have been reared from it, *Frontina frenchii* Will., from Washington, D. C., and vicinity, and *Belvosia bifasciata* Fab., from northern Missouri. Among the old Riley notes is a record of the rearing of an egg parasite, but the species has not been determined.

At one time the electric lights in some of the large cities mentioned were the means of attracting and destroying large numbers of the moths, and both moths and caterpillars were destroyed in large numbers by passers-by, who trampled on them.

As a rule little is to be expected from tachina flies as a means of controlling insect pests, and the ichneumon mentioned, being a general parasite, is not an efficient destroyer of this particular species. In

^aThe other species concerned in damage were *Heterocampa guttivitta* Walk. and *H. bilineata* Pack., principally to forest trees, although during the year they injured maple groves and attacked sugar maple and a considerable variety of the forest trees in New England.

^bLawrence Bruner, 1890, Bull. 14 Nebr. Agr. Exp. Sta., pp. 54-59.

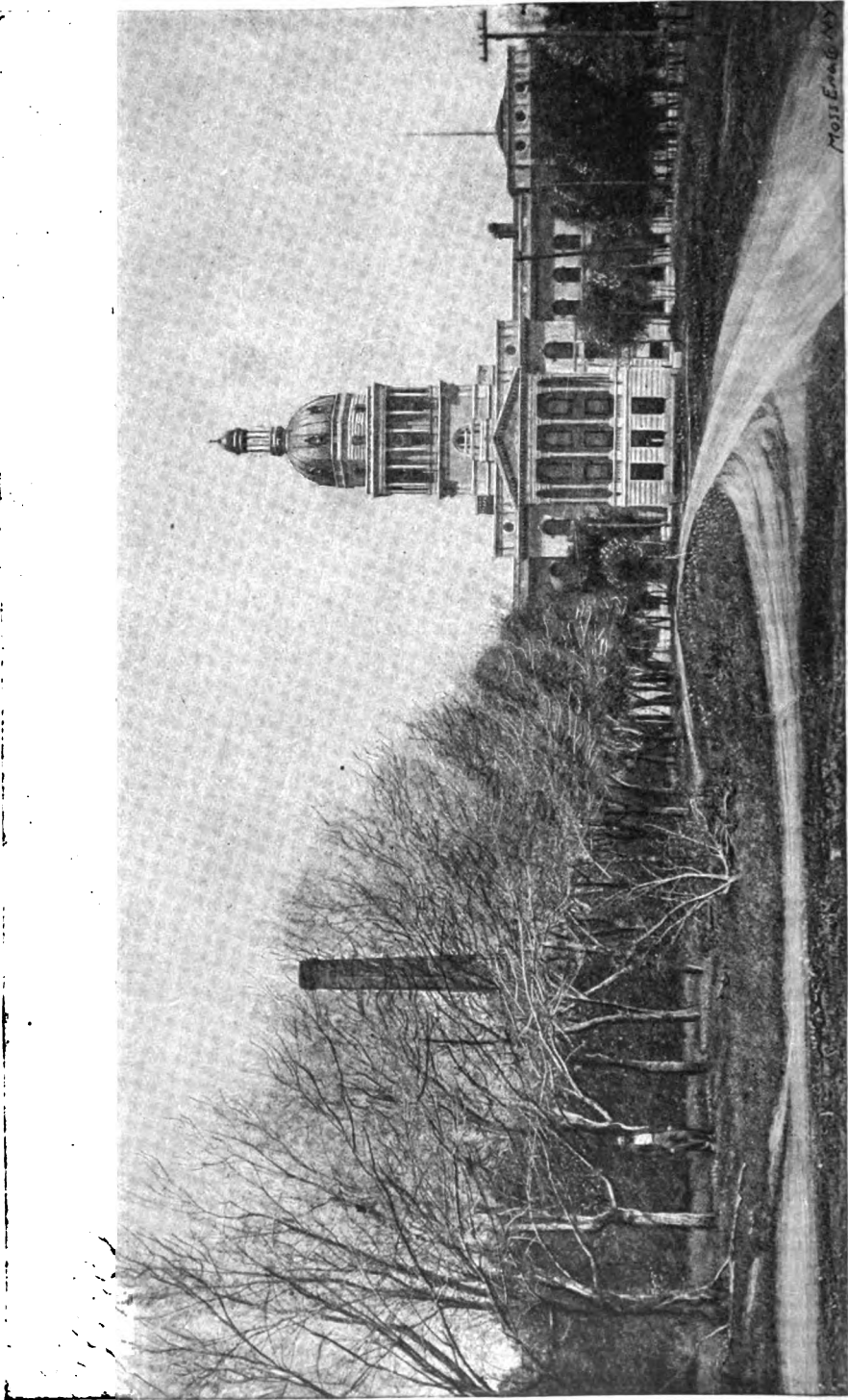


FIG. 2.—State Capitol at Lincoln, Neb. showing trees defoliated in 1900 by the smoke and

other words, we can not rely for assistance upon any of the natural enemies except birds. These should be encouraged in every possible way, and warfare should be waged against the English sparrow, which does not feed on this caterpillar, save perhaps occasionally in nesting time, and is a great pest in itself, especially as it drives other and useful birds from cities and towns.

REMEDIES.

Arsenicals.—Spraying with an arsenical mixture, if accomplished when the caterpillars are young, is the most effective means of controlling this insect, but a spraying is not easily applied when a large grove of maples is infested. Either Paris green or arsenate of lead may be used and applied in accordance with the directions furnished for other shade-tree defoliators, as described in detail in Farmers' Bulletin No. 99. This publication should be in the hands of all persons suffering from the ravages of shade-tree insects, and that portion relating to general instructions in the last chapter should be read.^a Paris green may be applied on maple trees as strong as 1 pound to 50 gallons of water, but half that strength, or one-half pound to 50 gallons of water, will probably suffice in most cases. Arsenate of lead may be safely used at as high a rate as from 2 to 4 pounds of the poison to 50 gallons of water.

Trenching.—If an arsenical spray has not been used while the larvæ are young, large numbers of the pests may be trapped and easily destroyed by digging a trench either around individual trees or around groves or belts of trees. The trench should be at least a foot deep, with the outer walls sloping under. The larvæ usually wander away from the trees before entering the earth, and will be caught in the trench in great numbers or will bury themselves in the ground in the bottom of the trench, where they can be killed. This remedy was given a practical and thoroughly satisfactory test many years ago by Doctor Riley, and has been recommended to our correspondents generally.

Hand picking.—When the public once becomes well acquainted with this insect in all of its stages, from the egg to the moth, large numbers of the eggs and the moths can be killed by hand on their appearance in May or June, and individual choice trees may in a measure be protected in this manner.

Approved:

JAMES WILSON,

Secretary of Agriculture,

WASHINGTON, D. C., May 26, 1909.

^aFarmers' Bulletin No. 99 is furnished gratis on application to the Department of Agriculture.

The first part of the paper is devoted to a discussion of the general principles of the theory of the structure of the atom. It is shown that the structure of the atom is determined by the laws of quantum mechanics, and that the laws of quantum mechanics are in agreement with the experimental facts.

In the second part of the paper, the author discusses the problem of the structure of the nucleus. It is shown that the structure of the nucleus is determined by the laws of quantum mechanics, and that the laws of quantum mechanics are in agreement with the experimental facts. The author also discusses the problem of the structure of the nucleon, and shows that the structure of the nucleon is determined by the laws of quantum mechanics, and that the laws of quantum mechanics are in agreement with the experimental facts.

The third part of the paper is devoted to a discussion of the problem of the structure of the elementary particles. It is shown that the structure of the elementary particles is determined by the laws of quantum mechanics, and that the laws of quantum mechanics are in agreement with the experimental facts. The author also discusses the problem of the structure of the elementary particles, and shows that the structure of the elementary particles is determined by the laws of quantum mechanics, and that the laws of quantum mechanics are in agreement with the experimental facts.

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